High Brightness Source Collector Module for EUV Mask Metrology

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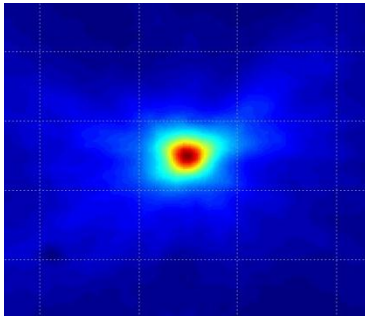
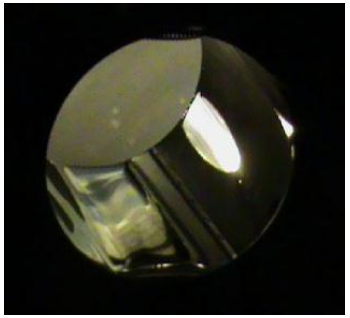




Outline

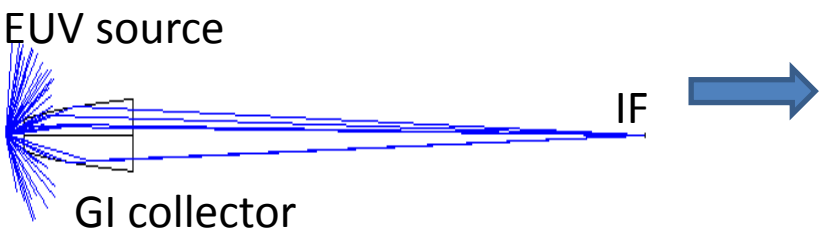
- Mask Metrology Requirements
- High Brightness SoCoMo
- LPP Source Characterisation
- The Collector
- Summary

Metrology Source Considerations

Tool Requirements*		
Metrology Tool	Etendue	Brightness
AIMS	$5x10^{-4}$ mm^2sr	30-100 W/mm^2sr
Mask Blank	$4x10^{-3}$ mm^2sr	> 80 W/mm^2sr
Patterned Mask	$1.5x10^{-2}$ mm^2sr	> 40 W/mm^2sr

Choices for etendue matching:

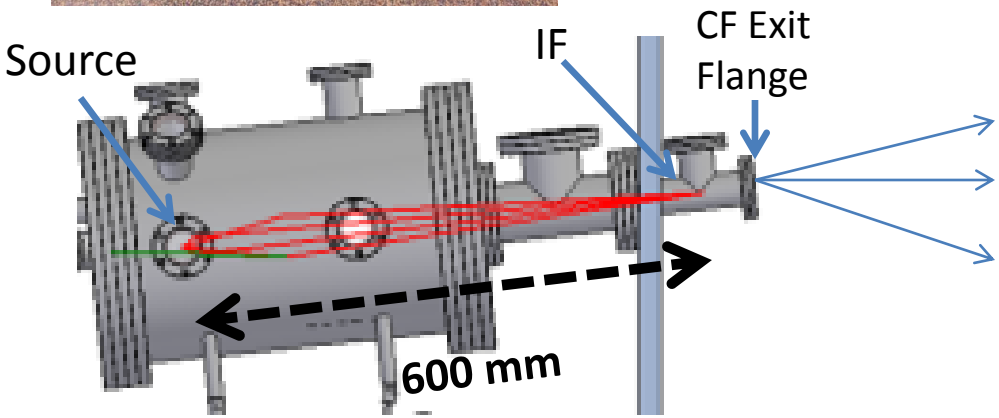
- Demagnify large source – photon loss for fixed etendue
- Magnify small source - higher photon collection
  - higher brightness for given input power



Magnifying ellipsoid (x8)
Placed < 20 mm from EUV Source
Etendue ≥ 10^{-4} mm^2sr
High Brightness

High Brightness SoCoMo

- Size 1 X 1 X 1.5 m^3
- High brightness LPP source
- Proprietary metal mixture
- Clean photons at IF
- Scalable (avg. power, brightness)
- Brightness roadmap to >1 kW/mm^2sr



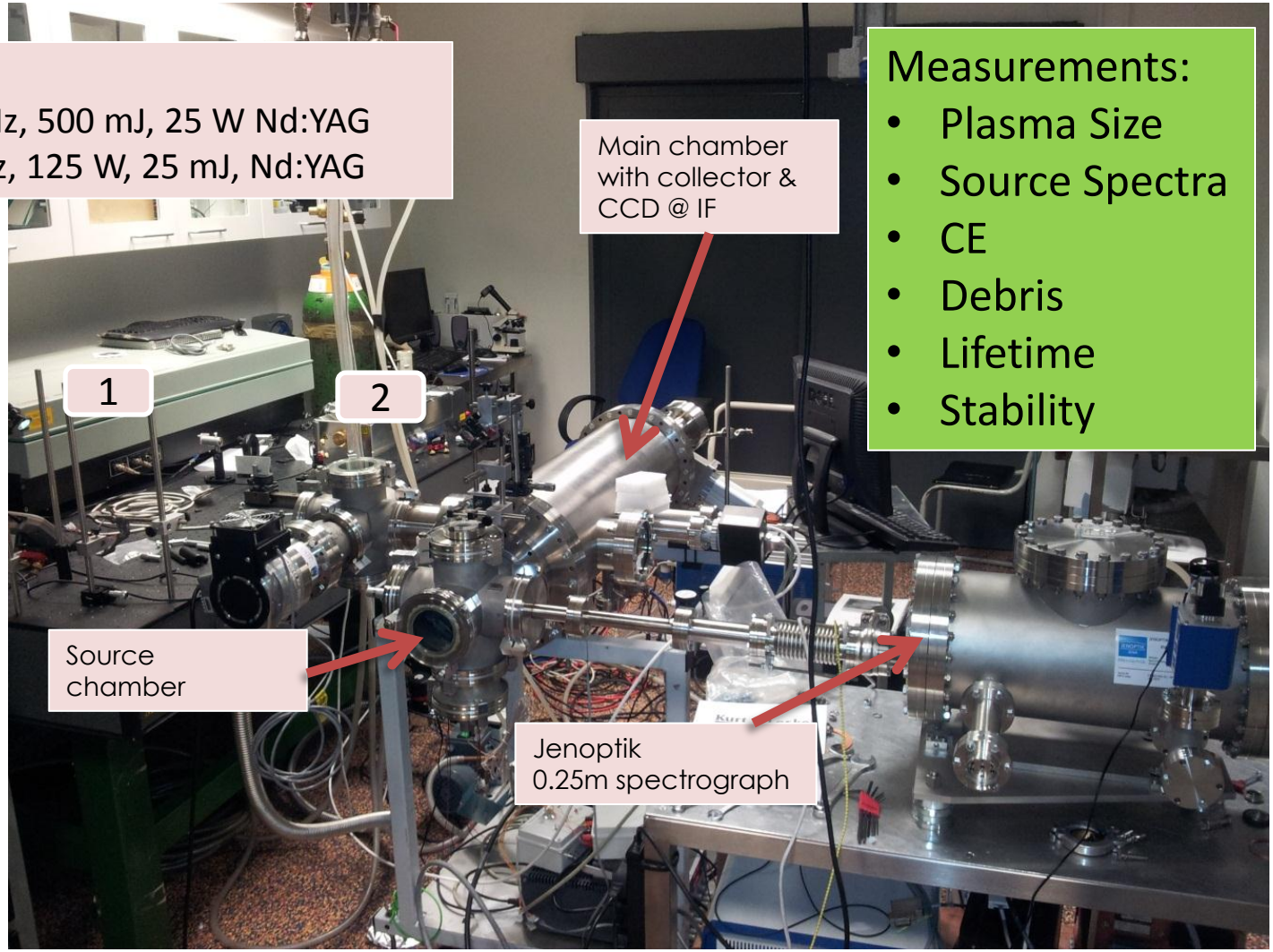
AIMS tool

Mask Blank tool

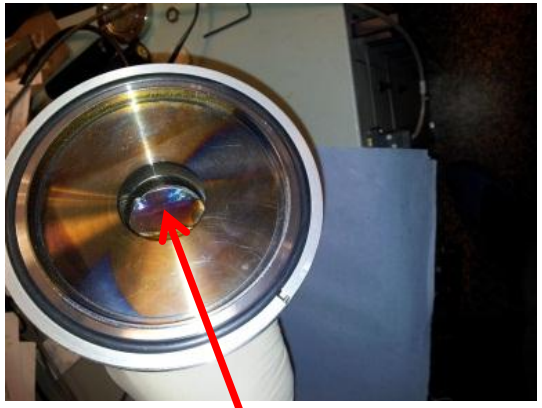
Patterned Mask tool

High Brightness SoCoMo

SoCoMo Characterisation Setup

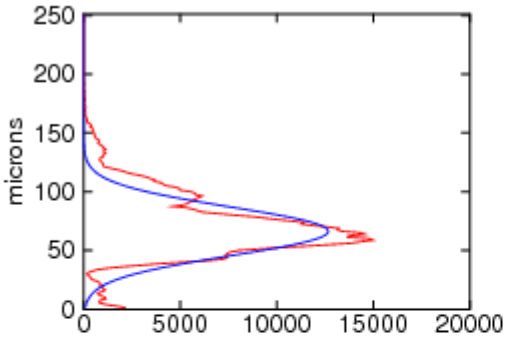


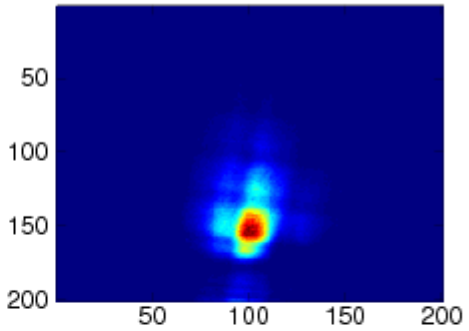
Source Imaging



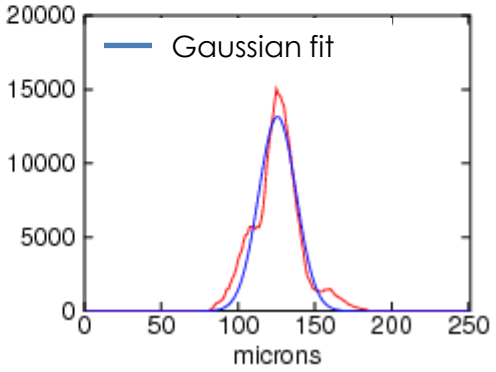
Mo/Si concave mirror
1mm dia clear aperture
Mag = 10.36

- 20 mJ laser input
- imaged at 13.5 nm



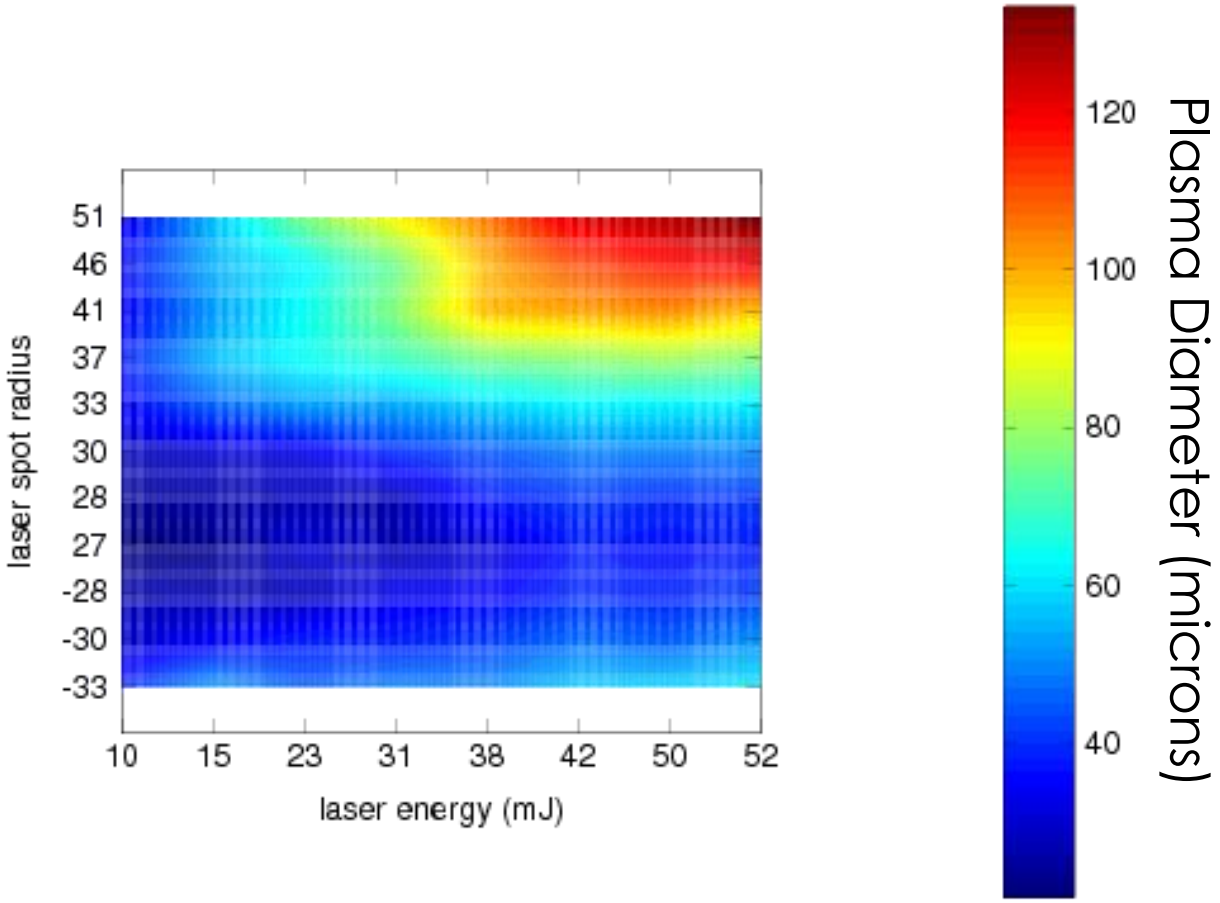


Plasma FWHM of 35µm observed

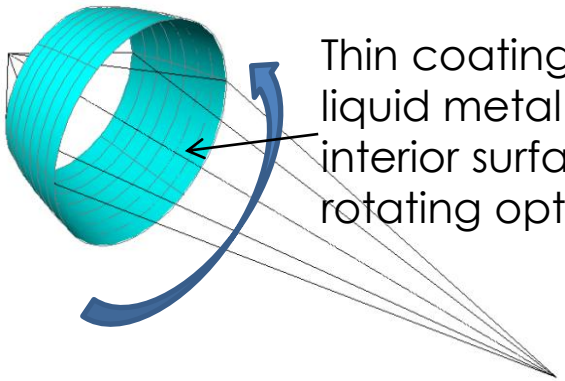


Source Imaging

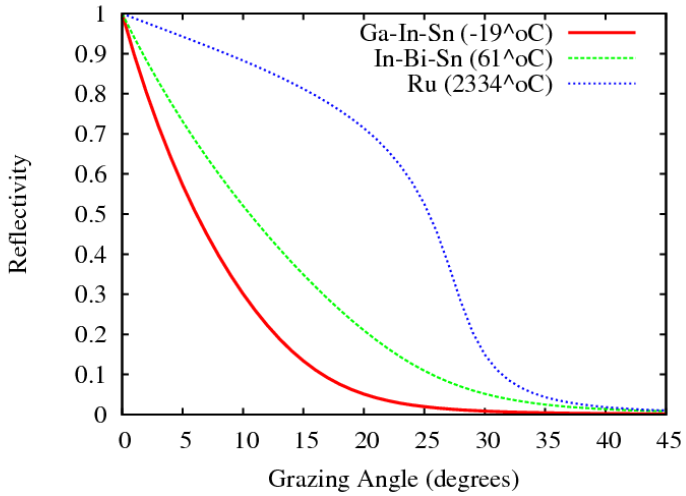
Plasma size v laser pulse energy trade-off

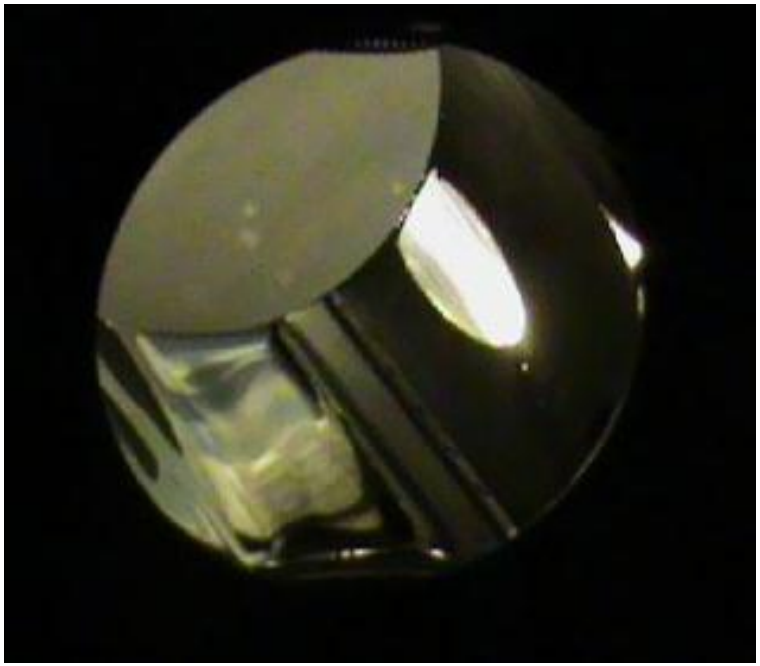


The Liquid Metal Collector



Thin coating of liquid metal on interior surface of rotating optic



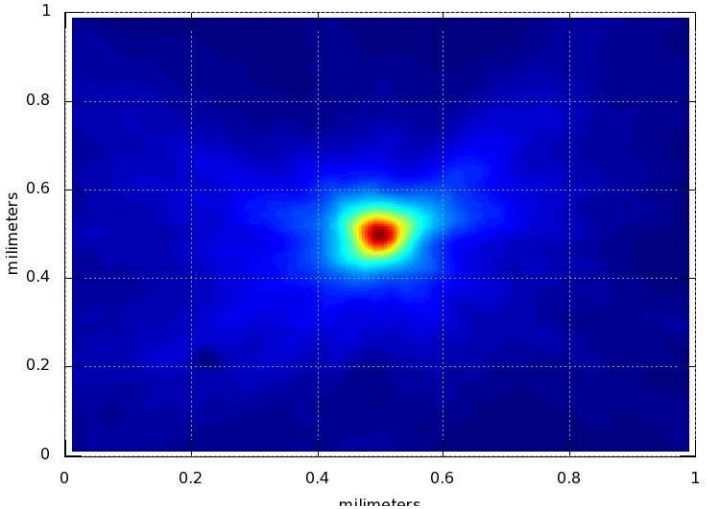


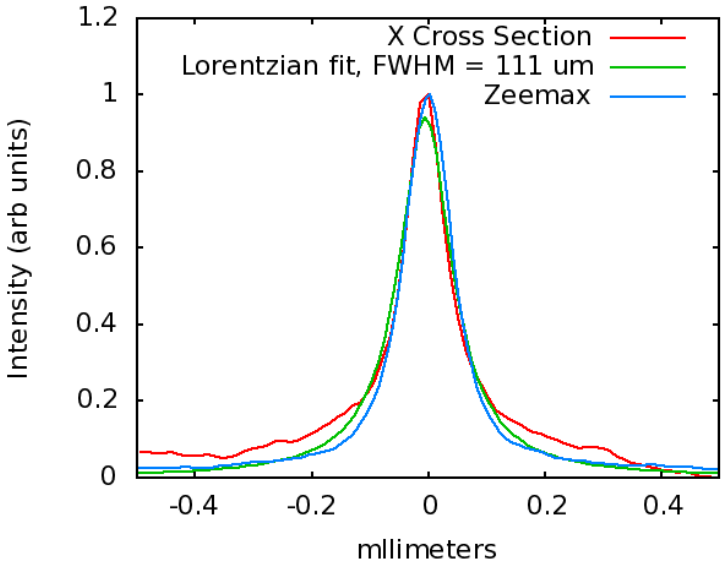
Collector design example:
Coating GaInSn
Length = 100 mm
Large Diameter = 40 mm
Collection ~ 3%

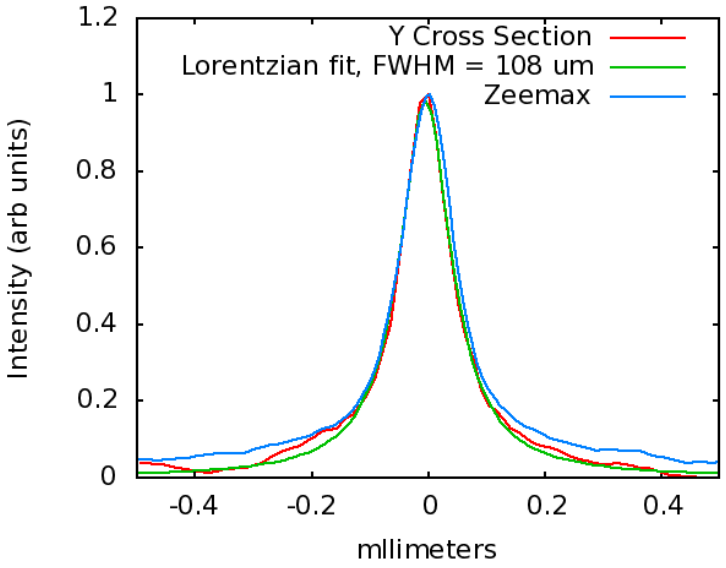
Optimising:
Collection efficiency
IF brightness

EUV Test Data at IF - LPP

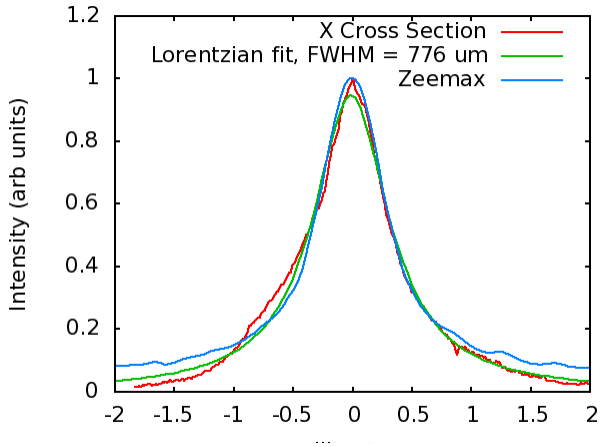
- GaInSn LPP source
- ~50 mJ on target
- Plasma size ~60 µm

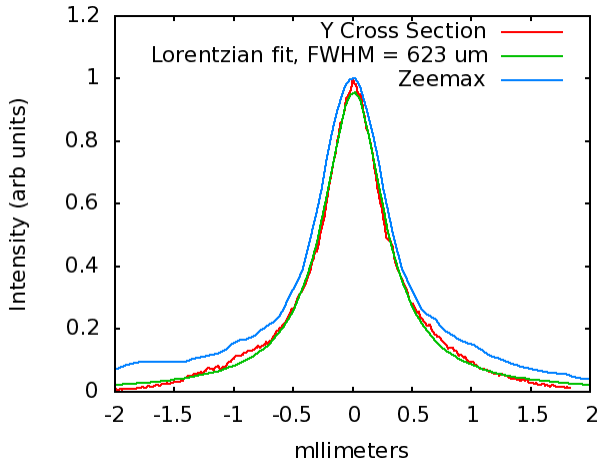


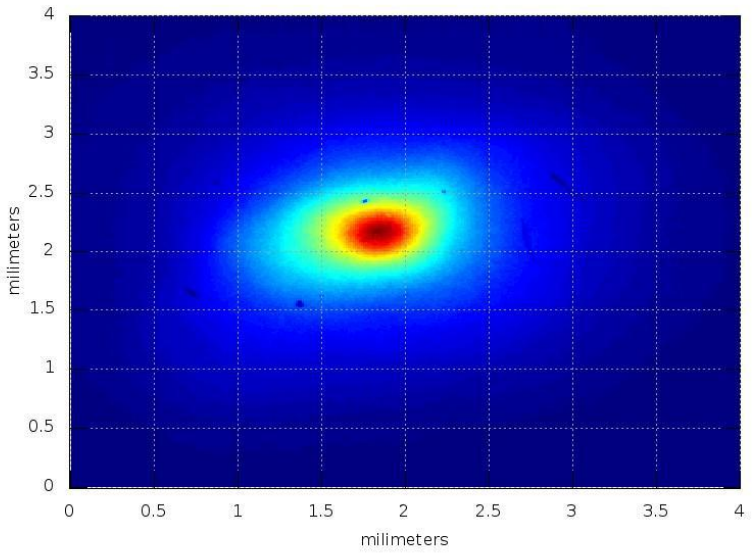




EUV Test Data - DPP



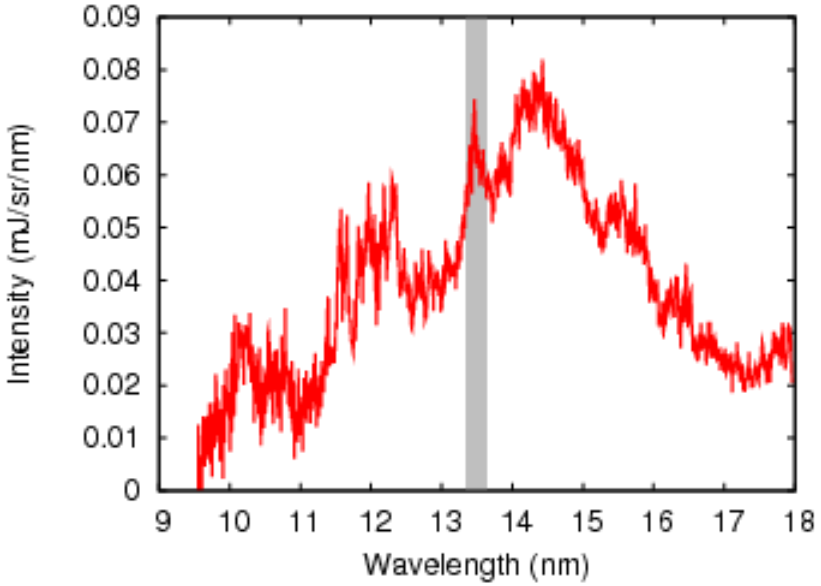




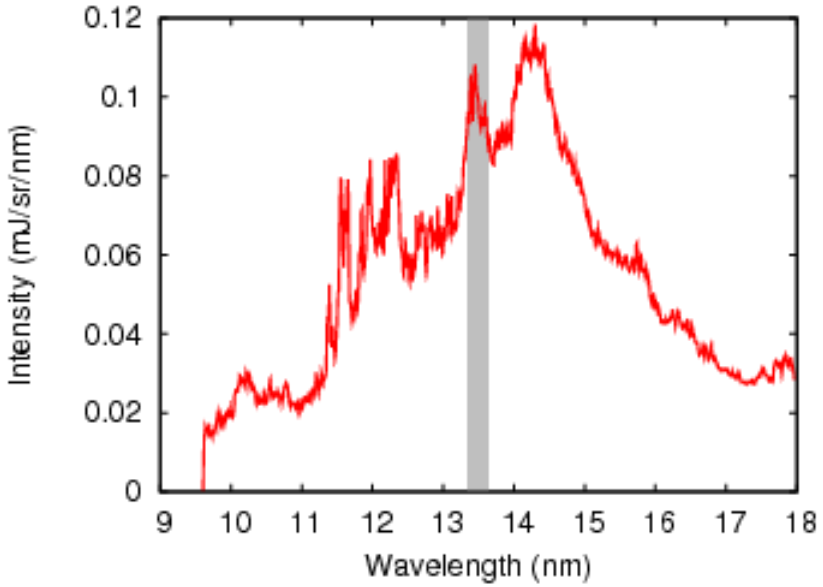
- *FWHMx= 776 µm, FWHMy= 623 µm*
- *Zemax DPP source model*
  - *Lorentzian pinch , FWHM = 420 µm*

Latest Source Spectra

Nd:YAG, 15 mJ per pulse, 50 Hz



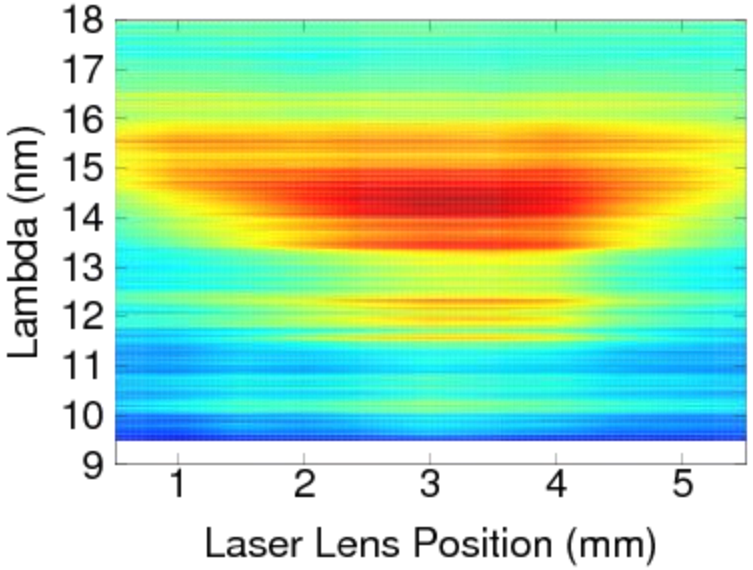
Nd:YAG, 17 mJ per pulse, 1 kHz



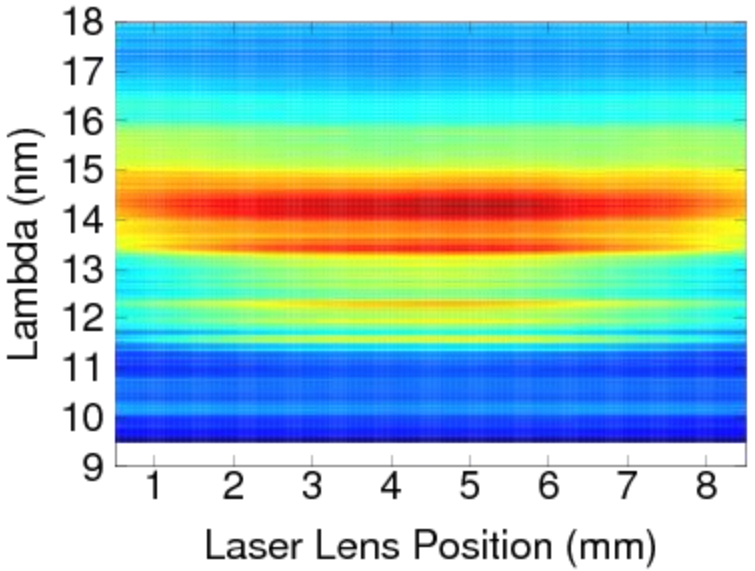
CE > 1% measured
CE > 2% expected

Latest Source Spectra

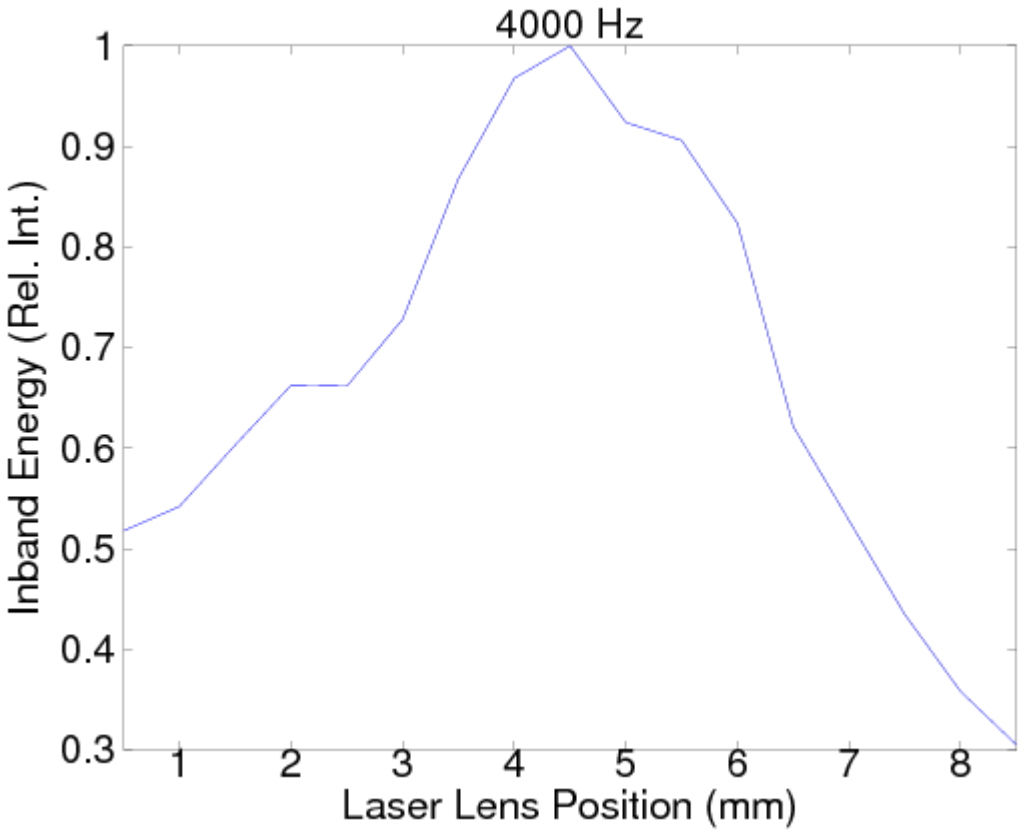
Nd:YAG, 15 mJ per pulse, 50 Hz



Nd:YAG, 17 mJ per pulse, 1 kHz



Measurements at 4 kHz ….First Results..



- Demonstrated Source brightness > 100 W/mm^{2}sr
- CE, source size, stability under optimisation

Brightness, Scalability, Reliability

- Smaller source sizes with next generation focusing optics
- Optimise CE @ 5 kHz
- Source and IF brightness measurements with 5kHz 125 W LPP
- Extend collector lifetime data using125 W LPP
- Upgrade to 500 W laser for 1kW/mm^{2}sr brightness

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Thank you for listening!

NewLambda Technologies

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